HAL open science

Towards a checklist for identification of atypical event scenarios

Nicola Paltrinieri, Mike Wardman, Nicolas Dechy, Ernesto Salzano, Valerio Cozzani

▶ To cite this version:

Nicola Paltrinieri, Mike Wardman, Nicolas Dechy, Ernesto Salzano, Valerio Cozzani. Towards a checklist for identification of atypical event scenarios. 2. iNTeg-Risk Conference 2010 "New Technologies & Emerging Risk : Dealing with multiple and interconnected emerging risks", Jun 2010, Stuttgart, Germany. pp.379-391. ineris-00976222

HAL Id: ineris-00976222

https://hal-ineris.archives-ouvertes.fr/ineris-00976222

Submitted on 9 Apr 2014

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

2010-344

Towards a checklist for identification of atypical event scenarios

Nicola Paltrinieri[1], Mike Wardman[2], Nicolas Dechy[3], Ernesto Salzano[4], Valerio Cozzani[1]

(1) Dipartimento di Ingegneria Chimica, Mineraria e delle Tecnologie Ambientali, Università degli Studi di Bologna, Bologna, Italy

(2) Health and Safety Laboratory (HSL), Fire & Process Safety Unit, Harpur Hill, Buxton, Derbyshire, United Kingdom

(3) INERIS, Parc Alata, Verneuil en Halatte, France

(4) Istituto di Ricerche sulla Combustione, Consiglio Nazionale delle Ricerche, Napoli, Italy

© British Crown copyright 2010

Corresponding author:

Nicola Paltrinieri
Dipartimento di Ingegneria Chimica
Mineraria e delle Tecnologie Ambientali
Università degli Studi di Bologna
Via Terracini 28
40131 Bologna
Italy
nicola.paltrinieri@mail.ing.unibo.it

Abstract

Proper hazard identification in safety reports has become progressively more difficult to achieve. Several major incidents in Europe in recent years, such as Buncefield and Toulouse, were not even considered by their site Seveso II Safety Case. One of the reasons is that available hazard identification (HAZID) methodologies take no notice of least likely or unknown events. Non-identified scenarios thus constitute a latent risk, whose management is extremely complex and open-ended. Hence this work aims to investigate the issue of atypical scenarios and explain how they could have been identified.

An in-depth historical analysis of some of these incidents has been performed, in order to outline general features of plants in which they occurred, their causes, consequences and lessons learned. This analysis has followed a precise common scheme, which allowed a systematic approach to the problem. Based on the findings, failures connected to risk management and risk appraisal have been identified. Checklist questions and recommendations will be compiled, making efforts to improve the general safety of industry. Attempts will be made to review well-known HAZID methodologies, and thus the process of risk appraisal, with the purpose of improving the HAZID processes to identify atypical scenarios.

1 Introduction

In recent years, Europe has witnessed the occurrence of two major accidents that had great relevance within society, because of the deaths, injuries and damages they caused, and also because of their peculiarity and unpredictability. Indeed, the incident scenarios that actually occurred were not taken into account by their site safety reports, thus rendering the operators unprepared for the emergency. Moreover, the whole risk governance was based on different kinds of incidents, which in certain ways may be considered less dangerous and easier to control. These atypical major accidents are the ammonium nitrate (AN) explosion at the AZF fertiliser factory in Toulouse (France) and the Vapour Cloud Explosion (VCE) at the Buncefield oil storage depot in Hemel Hempstead (UK).

This work shows an in-depth analysis of some of these unexpected incidents, in order to outline general features of plants in which they occurred, their causes, consequences and lessons learned. On the basis of the findings, well-known HAZID methodologies have been studied and developed, which will assist future HAZID processes used to identify atypical incident scenarios.

2 Historical incident analysis

2.1 Past atypical scenarios

The Toulouse incident occurred on 21st September 2001. An explosion took place in a warehouse, located among process, storage and packaging areas of the plant which mainly produced ammonium nitrate (AN), ammonium nitrate-based fertilisers and other chemicals including chlorinated compounds. Due to the vicinity of the plant to the city of Toulouse, the effects to people and the damage were catastrophic. The explosion caused 30 fatalities and damages estimated between €1,5 to €2,5 billion (Dechy and Mouilleau 2004). The warehouse was used as a temporary storage of 'off-specifications' AN. This incident scenario was not considered in the safety studies or in the Land Use Planning (LUP) safety perimeters (Salvi and Dechy 2005). In addition, the Seveso II directive did not cover the particular risk of 'off-specification' AN (Directive 96/82/EC). Today this kind of material with badly defined properties is classified in (Directive 2003/105/EC) at a risk level similar to technical grade AN.

AN is a strong oxidative material; AN-based products have led to several major accidents before 1950 (Table 1) with hundreds of fatalities and massive destruction due to the fact that the detonation properties were poorly understood. With quality driven standards, regulation frameworks and the promotion of better anti-caking agents (Marlair and Kordek 2005), very few explosion accidents have occurred since the middle of 1950's (Table 1). The major explosion in Toulouse was a severe reminder of the inherent hazards associated with the handling and storage of AN. Table 1 shows the more serious AN major explosions previous to Toulouse incident.

Similarly, despite the warnings about the extreme reactivity of ammonium nitrate, represented by several incidents before the middle of 1950s (outlined in Table 1), due precautions were not taken to prevent the risk of explosion. For instance, the group of buildings where the warehouse was located was not equipped with a fire detection system (Dechy et al. 2004). Also in this case the scenario that actually occurred had been underestimated due to the fact that the hazard identification process failed to identify the risk.

In both the cases the incident scenarios were not deemed sufficiently credible to be captured by current HAZID methodologies, but with hindsight it can be stated that they represent a real and impending risk to industry and society. Thus, the current contribution aims to outline lessons and recommendations, and to define a different approach to the hazard identification process that should help in identifying little known incident scenarios such as those which occurred at Buncefield and Toulouse.

Scenarios of this kind, normally excluded by risk assessments, from this point on will be named as atypical scenarios.

2.2 Methodology approach of historical incident analysis

The methodology of historical incident analysis is a way to better understand the actual mechanisms of past accidents in order to avoid them in the future. The atypical incidents mentioned (Buncefield and Toulouse) had some similar precedents, knowledge of which might have helped in the safety assessment process, in order to foresee the atypical scenarios that occurred. Hence, the development of a method for analysing past incidents may allow better knowledge management and horizon scanning, which will lay the foundations for a more general methodology of hazard identification.

In order to agree a systematic analysis of incidents, a common template for historical analysis has been outlined. It is divided into five parts concerning different aspects of possible incidents (Table 3).

Table 3: Historical incident analysis template

Part		Part items
A	General details of event and site	- Accident location - Date and time - Short description of industrial setting involved - Context of event - Area and stakes vulnerability
B	Event description	- Main scenario - Description of industrial process, substances and materials involved - Short description of incident and circumstances - Timeline of events
C	Causes and Consequences	- Initiating events and direct causes - Failures in ERMF Emerging Risk Management Framework - Failures in risk governance framework - Consequences and damages - Event management - After the event
D	Lesson learned and corrective actions	- Main findings and official lessons - Main official recommendations - Feedback on corrective action implementation - Diffusion of information and knowledge management

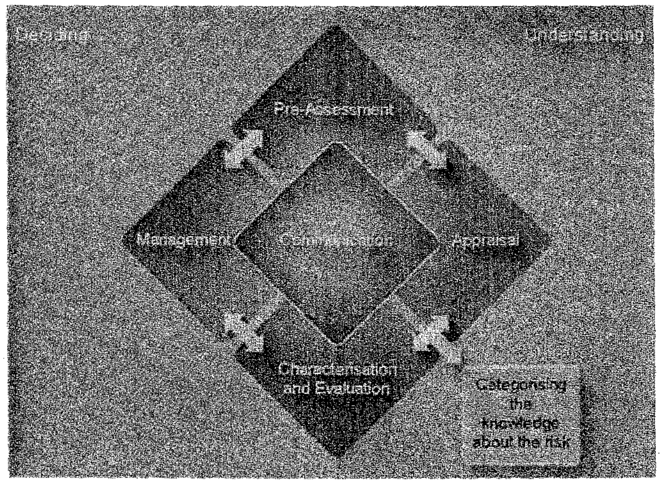

Figure 2: Risk governance framework
(iNTeg-Risk Description of work 2009)

A reference to these frameworks is a way to better organise and understand the root and direct causes of the incident. In this way, aspects of risk management that are lacking may be detected early and included in any subsequent analysis.

Consequences, damages, effects to system, people and environment are the other main topics of this section that also aims to describe the emergency response measures taken during the incident event and the actions to restore, repair and reclaim after the event.

Lessons learned from official investigations (following corrective action) are reported in part D in order to evaluate which aspects should be broadened and how they should be treated. Finally, part E reports sources of information and references used.

3 First results

Up to now, five major incidents have been analysed by means of the template described (see Table 4).

Table 4: Summary of atypical incidents analysed (Dechy et al. 2004) (MIIB 2008)

	Toulouse (2001)	Buncefield (2005)	St Herblain (1991)	Naples (1985)	Newark (1983)
Plant typology	Chemical and fertiliser plant	Oil storage depot			
Substances involved	Off-specification ammonium nitrate	Gasoline and fuel oils			
Main incident scenario	Reactive chemical explosion	Vapour cloud explosion			
ΔPmax (kPa)	150	200	50	80	/

Toulouse and Buncefield have been previously described and used as examples of atypical incident scenarios. St Herblain, Naples and Newark are quoted in Table 2 as vapour cloud explosions in oil depots caused by LOC of gasoline. Analysis has highlighted important aspects of the incident event and several failures of risk management, which would need corrective and resolving actions.

Plants involved in the incidents are characterised by the important fact that the dangerous substances stored could represent a threat to the nearby population (see Table 4). In fact in some cases these plants are located close to the urbanised area, as shown in Figure 3. The need to properly identify hazards in these cases is even more important.

3.1 ERMF failures – Technical, technological dimension

A clear example of failures of 'Technical, Technological' dimension of the ERMF is the event that triggered the incident of St Herblain. The direct cause to the incident was attributed to the failure of a rubber joint at the pipefitting (Figure 4) (Lechaudel and Pineau, 1992). The joint was guaranteed by the manufacturer to last with a maximum aromatic concentration of 30%. Instead, the incident occurred on the first day of operations with a 98-octane gasoline with an aromatic concentration of 55%. Gasoline released from the consequent leak poured into a retention basin, where it vaporised and led to a mist formation (enhanced by 100% humidity in the vicinity of the site).

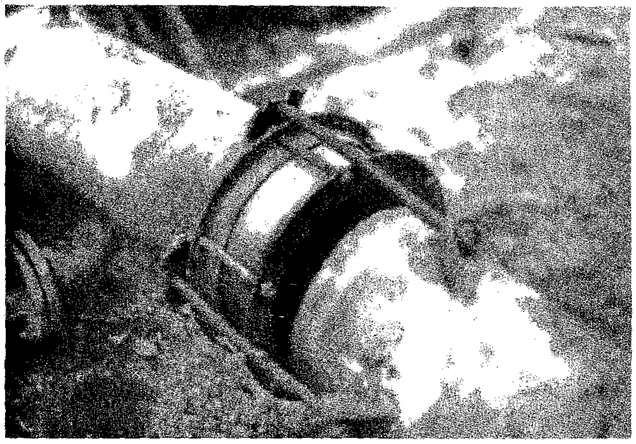

Figure 4: Location of the failing rubber joint at the pipe fitting

Another failure of this dimension of risk management can be identified in the design of Buncefield tanks, which may have contributed to the vapour/mist formation. Tests demonstrated (MIIB 2008) that a deflector plate on the top of the tank, like in Buncefield, channels only a part of the overfilling fuel onto the tank wall but the rest runs over the top of the plate, fragmenting into droplets. Moreover, fuel running down the wall could hit structural stiffening rings and become detached from the tank wall, creating another cascade of droplets (Figure 5). These conditions would promote the evaporation of the lighter components of petrol, such as butanes, pentanes and hexanes. The freefall of droplets leads to entrainment of air and mixing between the air and fuel vapour, and the formation of a rich fuel/air mixture.

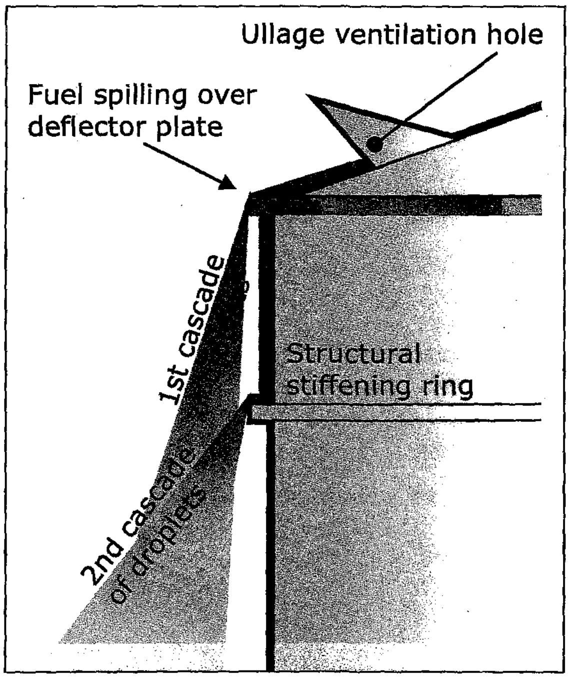

Figure 5: Pattern of fuel dispersion

four dimensions of ERMF framework. These recommendations emphasised the need to increase the technical protection provided by primary, secondary and tertiary containment systems in oil depots, without disregarding human and organisational factors. Recommendations address, amongst others, competent authority and central government leadership, in order to ensure these improvements and an early response to a major incident. Finally, as the case of the incident at Toulouse, it is suggested that a review of COMAH regulations (UK implementation of Seveso II) and LUP processes be carried out, ensuring that they are based on a simplified, generic approach to risk assessment for flammable storage sites (MIIB 2008).

4 Further development of work

By means of an historical analysis of atypical incidents, direct and root causes have been identified. These causes can be attributed to common events such as improper risk management or to a more general failure of ineffective hazard identification. The combination of these causes has led to the incident, as effectively explained by the 'Swiss cheese model' (Reason 1990) (Hudson et al. 1991). In this case the different slides represent the four dimensions of ERMF and the characteristic holes of the Swiss cheese symbolise the failures. Figure 6 shows the application of this model to the Buncefield case.

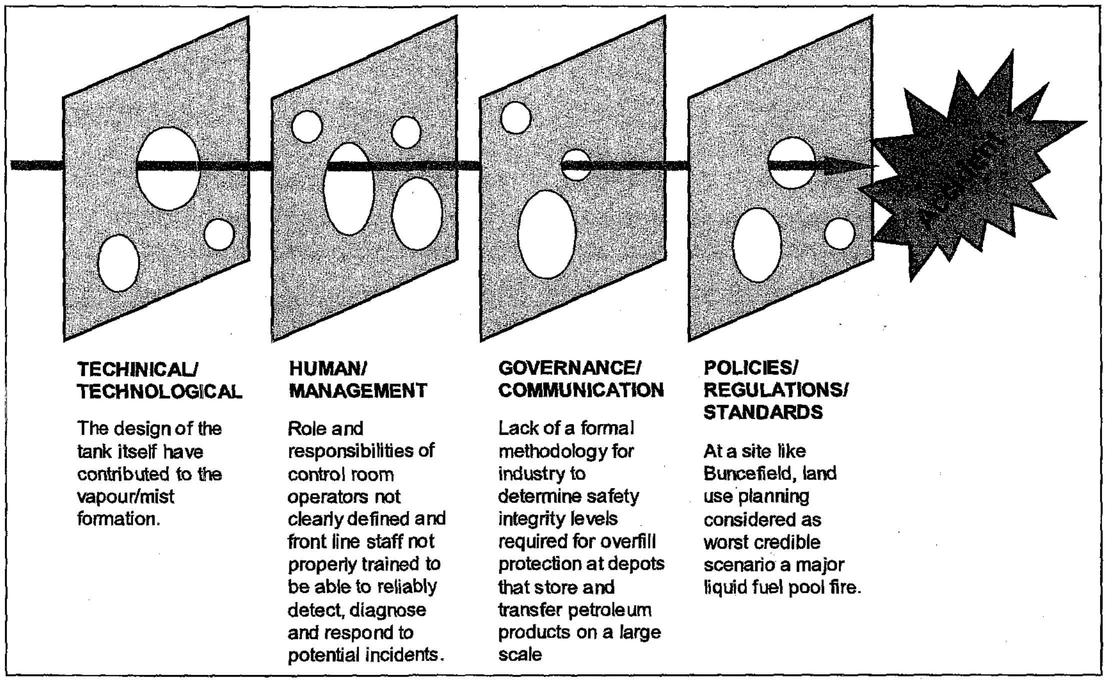

Figure 6: Swiss cheese model applied to ERMF Buncefield case.

With the purpose of improving risk management for these type of industrial plants and, thus, to close some of the holes in the cheese slices, checklist questions will be formulated, based on the lessons learned from past failures.

Moreover, to address the incapability of HAZID methods to capture atypical scenarios, a bow-tie methodology is being applied to plants involved in the accidents considered here. Figure 7 shows an example of an event tree referring to oil storage tanks of Buncefield oil depot.

6 References

Bouchard J. K. (1983), Summary Investigation Report of Gasoline Storage Tank Explosion and Fire, Newark, New Jersey, 07/01/1983, National Fire Protection Association.

Dechy N., Bourdeaux T., Ayrault N., Kordek M. A., Le Coze J. C. (2004), First lessons of the Toulouse ammonium nitrate disaster, 21st September 2001, AZF Plant, France, Journal of Hazardous Materials, volume 111.

Dechy N., Descourrières S., Salvi O. (2005), The 21st September 2001 disaster in Toulouse: an historical overview of the Land Use Planning, Proceedings of the 28th ESReDA Seminar on the Geographical Component of Safety Management: Combining Risk, Planning and Stakeholder Perspectives - Karlstad University, Sweden.

Dechy N. and Mouilleau, Y. (2004), Damages of the Toulouse disaster, 21st september 2001, Proceedings of the 11th In-ternational Symposium Loss Prevention 2004, Praha, 31 May - 3 June 2004. - Re-Published in the Loss Prevention Bulletin n°179 of October 2004 (Icheme).

Directive 2003/105/EC of 16 December 2003 amending Council Directive 96/82/EC on the control of major accident hazards involving dangerous substances.

Directive 96/82/EC of 9 December 1996 on the control of major-accident hazards involving dangerous substances.

Hudson, P. T. W., Groeneweg, J., Reason, J. T., Wagenaar, W. A., Van der Meeren, R. J.W., & Visser, J. P. (1991). Application of TRIPOD to measure latent errors in North Sea gas platforms: validity of failure state profiles. First international Conference on health, safety and environment. The Hague, NL: Soc. Petr. Eng.. pp. 725–730.

INTeg-Risk Description of work 2009, Annex I of Grant agreement for Collaborative Project (Large-scale integrating project), Project title: Early Recognition, Monitoring and Integrated Management of Emerging, New Technology Related Risks.

Lechaudel J. F., Pineau J. P. (1992), Accident investigation report, Analyse de l'accident du 7 Octobre 1991 à Saint-Herblain dans l'enceinte du dépôt pétrolier de la société GPN (Groupement Pétrolier de Nantes), INERIS/EXP-JLc z3/10 78-6782.

Maremonti M., Russo G., Salzano E., Tufano V. (1999), Post-accident analysis of vapour cloud explosions in fuel storage areas, Process Safety and Environmental Protection, Trans IChemE, 77, 360-365.

Marlair, G., Kordek, M. A., (2005), Safety and security issues relating to low capacity storage of AN-based fertilizers, Journal of Hazardous Materials, volume 123.

MIIB - Buncefield Major Incident Investigation Board (2008), The Buncefield Incident 11 December 2005, Final Report, HSE Books.

Reason, J. (1990). The contribution of latent human failures to the breakdown of complex systems. Philosophical Transactions of the Royal Society (London), Series B, 327, 475–484.

Salvi O., Dechy N. (2005), Toulouse disaster prompts changes in French risk management, Environment and Poverty Times, January 2005, 03, UNEP/GRID-Arendal (United Nations Environment Program).